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Introduction

1. INTRODUCTION

1.1 Background

The U.S. Department of Energy (DOE, or the Department) issued the *Draft Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada* (Draft EIS; DOE 1999, all), dated July 1999, in accordance with the National Environmental Policy Act of 1969, as amended (NEPA; 42 USC 4321 *et seq.*), and the Nuclear Waste Policy Act, as amended (42 USC 10101 *et seq.*). The Draft EIS describes the Proposed Action to construct, operate and monitor, and eventually close a repository at Yucca Mountain, and the potential environmental impacts of that action.

In December 1998 (before the publication of the Draft EIS), DOE published the *Viability Assessment of a Repository at Yucca Mountain* (Viability Assessment; DOE 1998a, all), as required in the 1997 Energy and Water Development Appropriations Act (Public Law 104-206, 110 Stat. 2984). The Viability Assessment provided information on the design of the proposed repository at that time, and stated that "DOE will continue to improve the repository design to provide extra margins of safety and will conduct additional research and testing to reduce remaining uncertainties" (DOE 1998a, Volume 1, p. 1-1). The Department began the evaluation of design options during the preparation of the Viability Assessment, as documented in the *License Application Design Selection Report* (CRWMS M&O 1999a, all). DOE completed this report in August 1999, after the publication of the Draft EIS. DOE selected a modified version of one of the five enhanced designs (Parker 1999, all) described in the *License Application Design Selection Report* for further design development.

In preparing the Draft EIS, DOE based the analysis on the Viability Assessment design (DOE 1998a, Volume 2), which represented the best available design information at the time. In the Draft EIS (DOE 1999, p. 2-6), DOE discussed its expectation that repository design features would continue to evolve. The evolution of the design is described in the *Yucca Mountain Science and Engineering Report: Technical Information Supporting Site Recommendation Consideration* (DOE 2001a, all), which summarizes technical information that the Secretary of Energy will use to determine whether to recommend approval of the Yucca Mountain site to the President for development as a repository.

This Supplement addresses the flexible design and operating modes presented in the Science and Engineering Report (DOE 2001a, all). This design (called the *S&ER flexible design*) reflects design enhancements and increased operational flexibility. The publication of this Supplement closely follows the publication of the Science and Engineering Report. Publishing these documents closely together assists in communicating the body of available design and environmental impact information before the completion of the Final EIS, and facilitates public review of comments on the S&ER flexible design. This Supplement refers the reader to specific parts of the Draft EIS, the Science and Engineering Report, and other documents for more information.

During the 45-day public comment period on this Supplement and in accordance with NEPA requirements, DOE will conduct one or more public hearings to receive oral and written comments on this Supplement. DOE will consider all comments postmarked within the comment period, and will consider comments received after the end of the comment period to the extent practicable.

1.2 Scope

DOE based the analytical scenarios in the Draft EIS (DOE 1999, Chapter 2) on the preliminary design in the Viability Assessment (DOE 1998a, all), focusing on the amount of spent nuclear fuel and its associated thermal output or load that DOE would emplace per unit area of the repository (called *areal mass*

loading). In the Draft EIS, DOE evaluated three thermal load scenarios including *high thermal load*, a relatively high emplacement density of commercial spent nuclear fuel [85 metric tons of heavy metal (MTHM) per acre], *intermediate thermal load* (60 MTHM per acre), and *low thermal load* (25 MTHM per acre). The analytical scenarios described in the Draft EIS were not intended to place a limit on the choices among alternative designs because DOE expected that the repository design would continue to evolve. Rather, DOE selected these scenarios to represent the range of foreseeable design features and operating modes and to ensure that it considered the associated range of potential environmental impacts.

REPOSITORY DESIGN TERMS USED IN THIS SUPPLEMENT

This Supplement evaluates the environmental impacts of the S&ER flexible design, which is the design focus of the *Yucca Mountain Science and Engineering Report: Technical Information Supporting Site Recommendation Consideration*. The evaluation includes the impacts covering a range from *lower-temperature* to *higher-temperature repository operating modes* (that embrace a range of operational parameters), as described primarily in Section 2.1.5.2 of the Science and Engineering Report. In this Supplement, the term *S&ER flexible design* refers to design features that are common to the range defined by the higher-temperature and lower-temperature repository operating modes. The differences between these modes deal with the highest postclosure temperatures of the waste package surface, the temperature of the emplacement drift rock walls, and the overall temperature of the repository rock. The term *Draft EIS design* refers to the repository design described in the Draft EIS; that is, the Viability Assessment design that could operate at a range of commercial spent nuclear fuel areal mass loadings, expressed as metric tons of heavy metal per acre, which define scenarios expressed as low, intermediate, and high thermal loads.

Since issuing the Draft EIS, DOE has continued to evaluate design features and operating modes that would reduce uncertainties in or improve long-term repository performance and improve operational safety and efficiency. The result of the design evolution process is the development of the S&ER flexible design, the potential impacts of which this Supplement evaluates. The S&ER flexible design incorporates certain design enhancements, but the basic elements of the Proposed Action to construct, operate and monitor, and eventually close a geologic repository at Yucca Mountain are unchanged.

In contrast to the focus of the Draft EIS on areal mass loading, the S&ER flexible design focuses on controlling the temperature of the rock between the drifts, and on the surfaces of the waste packages and the drift walls to meet thermal management goals established for possible repository operating modes. As a consequence, the designs differ with respect to some operating parameters. For example, the S&ER flexible design differs from the design evaluated in the Draft EIS with respect to the range of areal mass loading considered – 25 to 56 MTHM per acre versus 25 to 85 MTHM per acre, respectively. The S&ER flexible design would achieve its thermal management goals by varying other parameters, such as the *linear thermal load* (heat output per unit length of emplacement drift, expressed in terms of kilowatts per meter). In addition, the S&ER flexible design could emplace waste packages relatively closer together than the Draft EIS design, which did not consider linear thermal load. Under the S&ER flexible design, DOE could vary other operating parameters such as ventilation rates and the blending of hotter and cooler spent nuclear fuel in the same waste packages.

This Supplement focuses on aspects of the design that have changed since DOE issued the Draft EIS. It explains how the potential environmental impacts of the S&ER flexible design compare to those analyzed in the Draft EIS, and provides a context for understanding the potential impacts of the S&ER flexible design (see Chapter 3).

The design evolution evaluated in this Supplement resulted from new information, including an improved understanding of the interactions of potential repository features with the natural environment and the addition of design features for enhanced waste containment and isolation. Design features will continue to

evolve in response to additional site characterization information, technological developments, and interactions with oversight agencies.

In developing the S&ER flexible design, DOE considered the concerns expressed by the Nuclear Waste Technical Review Board about difficulties in reducing large uncertainties regarding waste package and repository performance related to high (above the boiling point of water) repository rock temperatures associated with the preliminary design in the Viability Assessment (Cohon 2000, all). The Board suggested that it might be possible to reduce such uncertainties by developing an adequate technical basis for a lower-temperature repository design.

The S&ER flexible design includes the ability to operate the repository in a range of operating modes that address higher and lower temperatures and associated humidity conditions. *Higher-temperature* means that at least a portion of the emplacement drift rock wall would have a maximum temperature above the boiling point of water at the elevation of the repository [96ºC (205ºF)]. The *lower-temperature* operating mode ranges include conditions under which the drift rock wall temperatures would be below the boiling point of water, and conditions under which the waste package surface temperatures would not exceed 85ºC (185ºF). To bound the impact analysis, DOE considered conditions under which the rock wall temperatures would be above the boiling point of water, and conditions under which waste package surface temperatures would not exceed 85ºC (see Section 2.2).

As with the thermal load analytical scenarios analyzed in the Draft EIS, the range of operating modes under the S&ER flexible design is representative of the range of foreseeable future design features and operating modes, and the conservative estimates of the associated potential environmental impacts in this Supplement encompass or bound the potential impacts of foreseeable future repository design evolution.

DOE will address all aspects of the Proposed Action, such as the transportation of spent nuclear fuel and high-level radioactive waste and the No-Action Alternative, in the Final EIS. Because the repository design has evolved from that considered in the Draft EIS, the Final EIS will evaluate only the S&ER flexible design, including the reasonable range of operating modes, and any enhancements to the flexible design developed as the result of ongoing analyses. DOE invites comments on its intention not to address the Draft EIS design in the Final EIS.

1.3 Document Organization and Contents

Chapter 2 describes the evolution of the design from that presented in the Draft EIS. It describes relevant aspects of the design evolution for the purpose of determining a basis for evaluating the environmental impacts in Chapter 3. In addition, Chapter 2 introduces and describes design concepts for two repository operating modes: higher-temperature and lower-temperature.

Chapter 3 provides an evaluation of how the potential impacts of the S&ER flexible design compare to the impacts analyzed in the Draft EIS.

Appendixes A, B, C, D, and E contain a list of references cited in this Supplement, a glossary of terms used in this Supplement, the list of Supplement preparers, a distribution list, and an index, respectively.